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By Professor J. T. Wilson, delivered before the Medical Society in the Vesalius Theatre, Medical School.

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By PROFESSOR J. T. WILSON, delivered before the Medical Society in the Vesalian Theatre, Medical School.

Some apology is, perhaps, due to you on account of the subject upon which I have chosen to address you this evening. Probably a large majority of those here present have already this year listened with pleasure and profit to the very able and interesting sketch of certain epochs in the history of medicine with which Dr. Smith terminated his last year's presidency of this Society.

It is possible that you may feel that it might have been wiser for me on this occasion to have avoided an immediate return to the historical aspect of medical science.

On the other hand there is something to be said for the contrary view. It is, perhaps, precisely when an interest has been awakened in the historical aspect of medicine, that we may with most advantage make the attempt to ascertain in somewhat greater detail what have been the precise phases of some particular problem of the science.

I readily admit that the one which I have chosen for consideration this evening may be regarded as somewhat trite and hackneyed. Yet, in the nature of the case, a predominantly students' society must always contain a number of junior members to whom that which to some may be a well-worn theme is by no means wholly familiar.

And, for myself, I confess that I find it always an invaluable intellectual discipline to make the attempt to climb down, as it were, from the shoulders of our more immediate predecessors—a vantage-position to which alone we owe our relatively clearer and more extensive views—and to try to place ourselves in the position and attitude of the men of an older time, so as to realise in some degree how those matters, which to us seem simple and obvious, and even commonplace, really looked to them.

A genuine success in this attempt is, of course, impossible of attainment. We are too much the intellectual creatures of our own time—the structure of our minds is so complexly interwoven with the ideas and the data of modern knowledge to be able really to assume the scientifically unsophisticated attitude of the older world, either ancient or mediæval. Yet the experiment will be well worth the trial. If we cannot realise the impossible, neither shall we fail of substantial gain. We may confidently look to arrive at a fuller and riper understanding of the real nature of progress in scientific knowledge. We can hardly fail to profit by an appreciation of the earnestness, perseverance, and devotion of the old searchers after the truth of Nature; and in a more sympathetic recognition of the comparative reasonableness—relative to their time—of views which otherwise are apt to appear to us as merely crude, incongruous, and grotesque.

It is a just pride which we all feel in the achievements of modern civilization, both in theoretical knowledge and in its practical applications. But that is a shallow and unthinking criticism which seeks to exalt the present by depreciation of the past, and which

turns aside from any survey of the pit from whence modern science has been digged, and the foundations upon which the superstructure of later attainment has been reared.

Let us make no mistake about the character and the calibre of the old masters of scientific investigation. There were giants in those days. If their ideas occasionally sound whimsical and preposterous, so that we find ourselves unable to repress a smile, this is in large part owing to our own limitations. We read them as the man in the street reads history, without that historical sense which alone yields the power, and confers the right to criticise.

The distinction or differentia of earlier science from that of to-day is not to be sought for merely in the limitation of the former in the material means of investigation in the way of tools and instruments, great as that limitation may be. It will become intelligible to us only when we in some measure apprehend the real character of the culture and intellectual attitude of the men of those times, and of the civil and ecclesiastical institutions which constituted their social environment.

Finally, it must not be forgotten that progress and attainment are commonly enough realised only through error and mistake. The contributions to the growth of knowledge by some of the greatest minds of the past now seem often enough to have been of negative rather than of positive value. They have advanced truth by exhausting some of the possibilities of error :

> " God's gift was that man should conceive of truth,
> And yearn to gain it, catching at mistake
> As midway help till he reach fact indeed."
> —" A Death in the Desert."

In tracing the historical development of the problem of the circulation of the blood we have first to take account of the contribution made by the science of ancient Greece to the knowledge of the structure and working of the animal body. And this constituted no mean heritage. Had the pursuit of scientific inquiry from that time been a continuous one, even if carried on ever so slowly, but in similar spirit, the later discovery of the secret of the circulation must have come ages before it did.

But upon the work of scientific investigation, as upon so much else of apparently even greater practical importance, there fell the deadly blight of that imperial decadent spirit which withered the enthusiasm and stifled the interest of those upon whose shoulders should properly have fallen the mantle of the earlier investigators.

After the decay of the Roman Empire there succeeded that long period of centuries which we are accustomed to designate as the dark ages. No greater mistake could be made than to regard this period as a mere blank hiatus in the history of civilisation, as the enthusiast for natural science is rather prone to do. But it cannot be denied that it was an extraordinarily barren and slumberous period in all that concerns the advancement of knowledge of the phenomena of nature. It is hardly too much to say that during its entire course no man with clear and audible voice dared himself to interrogate Nature directly concerning her secrets. More especially the authority of Galen, in anatomy and medicine, rivalled in its tyrannous supremacy the empire of Aristotle over other departments of human thought.

After the mediæval slumber came that period of awakening which we call, so significantly, the new birth or Renascence. And a roll of names of illustrious anatomists at the beginning of and throughout the sixteenth century bears witness to the prominence of

anatomical research as one of the earliest embodiments of the new spirit of scientific inquiry.

I shall only attempt very briefly to set forth the views held in ancient times on the subject specially before us this evening.

It is appropriate to begin with a reference to the views of Hippocrates ("The Great"), "the father of medicine." The leading known facts and features of his personality and work were well epitomised for you by Dr. Smith. He was born at Kos in 459 B.C. His general doctrine of Nature was that of his elder contemporary, Empedocles (440 B.C.) It was that of the four elements—earth, water, air and fire.

In the body, too, were four basis fluids—blood, mucus, yellow bile and black bile. The yellow bile was the product of the liver, and black bile of the spleen.

His knowledge of anatomy appears to have been derived chiefly from dissections of animals, but in all probability most of his writings that deal with anatomy have been lost.

In reference to the heart there is evidence that he recognised the existence of the semi-lunar valves, which he speaks of as being air and water-tight, at least in the left side. The left ventricle, or its fluid contents was, according to him, the seat of soul. An idea which no doubt even yet underlies several of the metaphors of modern speech.

Arteries, veins, the ureters, and even the nerves were regarded as tubular structures of indistinguishable character, except that as the arteries (proper) and the left heart were after death found empty, they, as well as the nerves, were held to contain the "pneuma" or vital spirit. The brain was at once the organ of thought and the source of the seminal fluid which reached the testes through the spinal cord. The bronchi were credited with the conveyance of fluid nourishment, as well as air, towards the heart in order to moderate its beat.

Perhaps the greatest name in the history of ancient biological investigation is that of Aristotle. He was, as is well known, the immediate successor in philosophy and the personal disciple of Plato. He was born just three-quarters of a century later than Hippocrates, in 384 B.C. He died in 321 B.C.

A man of profound thought and wide observation, he assigned to himself all knowledge as his province. We are only here concerned with his views on animal structure and function. Apparently he never dissected the human body (he was, of course, not a physician by profession), but he has left well-known records of extensive operations upon the lower animals.

In passing it may be noted that his system of natural knowledge assumes the existence of a primitive original element or ether, out of which arise the four elements of Empedocles—fire, air, earth and water, with their respective fundamental properties of heat, dryness, cold and moisture. Fire and air are active, whilst earth and water are passive. The influence of these fundamental concepts can be traced down right into the thought of modern times, and even into the popular consciousness of to-day, through the determining effect of Aristotleianism in the scholastic philosophy, and through it upon the philosophical systems which have superseded it.

In animal bodies, according to Aristotle, these four elements combine to form the simple homogeneous parts of the body, as blood, serum, fat, marrow, milk, flesh, sinews, skin, hair, horn, bone, &c.; whilst the organs of the body arise from combinations of these simple tissues. We thus owe to him the first systematic scheme of a "General Anatomy" of elementary tissues or textures.

With special reference to the circulating system he describes and names the aorta (conduit), which he distinguishes from a thin-walled vein. But he fails to distinguish the pulmonary artery from the venal canal, or the ramifications of the latter from branches of arteries. He conceives the heart as the centre and origin of the blood vessels, and regards it as filled with blood.

The incomplete blood is borne, according to Aristotle, from the region of the intestines to the heart, both through the aortic and vena caval channels. In the heart—the central organ of the body and seat of the animal soil—it is elaborated and completed and kept fluid by the heat communicated to it by the heart. (The act of coagulation is obviously regarded as similar to the setting of a jelly by cold).

The heart itself is pretty accurately described except that only three chambers are noted from failure to recognise the double auricle.

The inherent properties of the heart are due to the presence of pneuma or "spirit" of life, which is inhaled into the lung in respiration, and reaches the heart by way of the pulmonary veins. This doctrine of a volatile, vital, fluid or spirit held the field in one shape or form for well nigh 2000 years, and still persists in speech metaphor and in the looser thinking of the popular mind.

The heart itself was regarded as a fountain or creator of heat. The pulsation of the heart was supposed to be due to the boiling up of the blood owing to the heart's heat. (Even to this day our blood "boils" and our hearts "wax hot within us" with a heat hardly to be assuaged by the rapid and exaggerated breathing of an outburst of passion!) Again, the entry of air into the chest cavity is due to the accumulation of heat in the heart, causing the movements of the latter to be communicated to the lungs.

Further, Aristotle was aware of the different colour of the two kinds of blood; but the fact is not connected with respiration, nor otherwise explained. The blood, animated by the heart's heat and impregnated with the *pneuma*, or spirit of life, is carried by the vessels (veins and arteries), which pulsate along with the heart, to all parts of the body, which it supplies as streams of water irrigate a garden.

Nothing is said of a return of blood to the heart, apart from the conveyance of the incomplete blood to the heart from the intestines. Apparently Aristotle believed that the aorta was itself a bloodless tube, though this is not consistent with some of his other statements.

The definite distinction of the arteries (formerly termed "leaping veins") from the veins we owe to Praxagoras, of Kos (circa. B.C. 300). He held that the arteries contained only the air-like vital spirit.

Two famous anatomists of Alexandria, Herophilus and Erasistratus, seem to have been the first to dissect human bodies, and Herophilus has therefore been styled "the founder of human anatomy." He was a native of Chalcedon, in Bithynia, and a pupil of Praxagora's, of Kos. He afterwards became physician to Ptolemy I., Soter (flor. B.C. 323-284).

Herophilus distinguished the arteries and the veins, recognising the differences in the thickness of their walls. He also held that the arteries partly contained blood, and that the pulse was communicated to them from the heart.

Erasistratus, of Julis (ob. 280 B.C.), was a pupil of Chrysippos, and also of Metrodorus, Aristotle's son-in-law. His views upon the relations of the arteries and the veins are of interest as bearing upon *the develop*ment of our problem.

The view then current, that the veins contained blood and the arteries only pneuma, seemed daily to be contradicted in cases of wounded arteries. Consequently Erasistratus devised the theory of "Synanastomoses" or communications between the arteries and veins, which were closed normally, but became open in some diseased and wounded conditions. The escape of the pneuma in the abnormal condition was conceived as determining the opening of the anastomosic channels from the veins, so that blood could then enter the arteries. By such ingenuity the preconceived view of pneumatic arteries was bolstered up.

We may pass next to consider the teaching of the man whose authority in anatomy and medicine was all-powerful in Europe for about 1400 years. It was still with the physiology of Galen, in one or other slightly modified form, that Harvey had to contend with in the promulgation of his new discoveries; and, even still, echoes of these old-world theories may still be heard reverberating in the popular consciences of to-day.

Claudius Galenus was born in Pergamos in the year A.D. 131 († 201 or 210). He was educated in Pergamos, Smyrna, Corinth (where he studied the anatomy of apes), and Alexandria, where he seems first to have had access to the study of the human skeleton. He practised medicine in his native town of Pergamos from the age of 28–34, and then emigrated to Rome, where he made himself famous by his lectures. He was a thorough eclectic. In his general principles he adhered to the Nature theory of Empedocles and Hippocrates, and he was an energetic upholder of the teaching of the latter.

Thus Galen's general physiological hypothesis is simply an extension of the Hippocratic or, rather, Empedoclean theory of the four elements. These are all equally blended in *blood*; *water* predominates in mucus; in yellow bile *fire* is the dominant element; whilst *earth* is the characteristic element of black bile.

The animation of organic beings is effected by the "animal soul." It is the various stages in the development of this which determine the great variety in the structure and function of living matter.

In man these processes depend upon a threefold manifestation of the pneuma or spirit imminent in him; first, as "natural spirit," whose specific organ is the liver, together with the veins of which it is the centre; secondly, as "vital spirit," whose specific organs are the heart and the arteries; thirdly, as "animal spirit," *i.e.*, the intellectual or nervous spirit embodied and manifested in the brain and nerves. This threefold classification of physiological activities must be directly correlated with the Platonic distinction of the reasoning soul in the brain, the animal soul in the heart, and the corporeally desiring and nutritive soul in the liver (compare also with the Pauline psychology).

Galen's views on the heart and blood vessels are not free from obscurity, and this has given rise to contradictory opinions as to some of his ideas. It is clear that he regarded the liver as the centre and source of the veins.

From the intestine the nutritive chyle was supposed to be led along the portal veins to the liver, there to be transformed into blood under the influence of the "natural spirits," with which also the new food-enriched blood is imbued. But this permeation of the blood by "natural spirits" in the liver leaves the blood yet crude, so far as the higher aspects of bodily functions are concerned. In this crude state it passes by the vena cava (inf.) to the right ventricle, and here,

under the influence of the heat of the heart, which is inherent, original and innate in that organ, the useful are separated from the useless constituents. The latter presently, in expiration, pass through the opened valves of the pulmonary artery, and are thus led off to the lungs and the outer world. But a portion of the crude blood, thus partly purified in the right ventricle, passes *through* the ventricular septum by numerous invisible pores, and enters the left ventricle. Here it experiences a still further change in the way of refinement and elaboration. During inspiration the pneuma is inhaled into the lungs, and this is actively drawn or sucked by the heart *during its expansion* along the pulmonary veins, or "vein-like artery," into the left breast. Here, again, under the influence of the inherent heat of the heart, and by a process regarded as a kind of fermentation, the pneuma is incorporated in the form of "vital spirit" with that portion of cruder blood which has transcended through the septum from the right ventricle. The "vital spirit" animates the blood with a higher and purer nature, and at the same time tempers and assuages the innate heat of the heart, preventing it from febrile excess.

Although Galen's anatomical description of the heart is, on the whole, fairly good, he denied its muscular character. According to his conception of its physiology, also, its active phase was that which we now know as the diastole, during which he held that the pneuma was drawn from the lungs to the heart.

Against previously received opinions, but fortified by the results of numerous vivisections, Galen maintained that the left ventricle also contained blood, although, in consequence of its mixture with the pneuma, it was distinguishable from that of the right heart and veins by its greater warmth and more volatile and vaporous constitution.

In addition to the movements of the blood, which have already been incidentally referred to, there is a continually recurring ebb and flow of the blood to and from the heart. Thus, from the right side along the veins (including the "vena arteriosa" or pulmonary artery) the grosser blood, endowed with merely natural spirit, flowed and then ebbed back to the heart again. From the left side of the heart along the arteries (including the "arteria venosa" or pulmonary vein) the refined and elaborated blood, animated by the "vital spirits," flowed and then ebbed back to the heart again. In the lungs this blood discharges its noxious vapours, derived from the fermentation of the crude blood in the left heart. In the brain the arterial blood, with its vital spirit, in turn generates the pure "animal spirits," which are a subtle, and volatile, and bloodless fluid, which is distributed through the nerves, producing movement and other higher operations of the bodily organisation.

This "animal spirit" was supposed to be generated, more particularly in the choroid plexuses, from the finest contents of the carotid artery.

Of the final fate of the blood Galen expresses no definite opinion, but only the general one, that it is wholly used up in the nutrition and animation of the parts of the body. There is no idea of a true passage of blood from arteries into veins, and a consequent return to the heart. Neither is there any recognition of a distinction between a greater or a lesser circulation. The blood in the pulmonary artery (or artery-like vein) only supplies the lungs with nutriment, and is not supposed to pass over into the pulmonary veins *(or vein-like artery).*

Such then was the state of knowledge that prevailed in the second century of our era with regard to the phenomena of the structure and action of what we now call the circulatory system. And such it remained, with practically little modification or addition, till more than 1300 years had passed away.

Indeed, as the centuries rolled by, more and more of the letters, as well as the spirit, of the ancient learning fell into oblivion amongst the nations of Christendom. Fortunately some of the ancient traditions were preserved, and a study of the ancient learning was still prosecuted by men of the Arabian and Moorish races, even throughout the darkest period of European neglect in art, literature and science.

This was the golden age of Arabian learning, and it was largely from the Arabian physicians that the West once more received the still glowing embers of the ancient culture from which was kindled the illumination of the Renascence period. The re-awakening of Europe began as early as the fourteenth century. No great progress was, however, recorded in anatomical science until early in the sixteenth century.

When we remember that the primary characteristic of the Renascence was that of a revival of learning—that it was at first distinguished by a passionate devotion to the spirit of antiquity rather than by immediate independent activity—we shall not be surprised to discover that the thread of anatomical study was at first taken up pretty nearly where it had been broken off centuries before. Once again men turned to Aristotle and Galen, but now with their eyes open and their minds liberated for the pursuit of knowledge in the same spirit as that of their masters.

At the beginning of the fifteenth century the explanations of the structure and working of the heart and blood vessels were almost identical with those of Galen.

Thus the veins were regarded as the chief blood vessels, and the liver as their source and centre. The arteries were believed to contain, at best, little blood, differing from the venous blood by its impregnation with vital spirits, of which latter subtle fluid they, the arteries, were held to be pre-eminently the conduits. The heart was considered as little more than a passive cistern generating the vital spirit through its intrinsic heat.

Blood was moved out of the heart, not by the action of the latter, but by expiration, which drove the blood to the lungs. It was then sucked back into the heart in inspiration. The flow of blood to the other parts of the body was conceived as a tidal flux and reflux, the outflow being determined by excitations set up in the parts supplied. Air was also supposed to be taken in by the arteries in diastole of the pulse through pores of the skin ; whilst, in sistole, fuliginous vapours were expelled in the same way. The lungs were looked upon as merely accessory to this process, the air entering, and the impure exhalations leaving the left heart in the arteries.

What a great gulf separates this system of physiological conceptions from those of our day !

The revolution was gradually prepared by a series of men, most of whose names are still enshrined for us in the nomenclature of the science.

First and foremost of these was he under the auspices of whose name we meet in this room—Andreas Vesalius—justly styled " the father of modern anatomy."

Andreas Vesalius (1514-1565), was Professor of Anatomy at Padua, under the Venetian Government, from 1539-1546. He also

taught at Bologne and Pisa. His epoch-making work on "The Structure of the Human Body," was published at Basle in 1543.

Vesalius definitely gave up the view that the liver was the origin of the veins, and he described the connections of the arteries and the veins more minutely than his predecessors. He mentions the valves of the veins, and describes minutely the valves of the heart, whilst he shows familiarity with the differences between the arteries and the veins.

It is important to note (1) that he seems to have recognised that it was the heart which propelled the blood into the arteries, causing the arterial pulse, and (2) that he maintained (unequivocally in his 2nd edition in 1555), as against Galen's views, that the partition between the right and left sides of the heart was not perforated, and that the blood of the left ventricle could not be derived from that of the right by direct communication. He seems to have been already quite sceptical on Galen's views in 1543, the date of his first edition, though he then still taught the Galenic physiology to his pupils.

The outstanding merit of Vesalius was his constant direct appeal to first-hand observation, then a new method in the pursuit of knowledge, and never wholly neglected since that fertile period.

Three other names may be specially mentioned as worthy of note amongst the predecessors of Harvey. These are those of Servetus, Realdus Columbus, and Andreas Cæsalpinus.

Michael Servetus was born in 1511, three years before Vesalius. He is best known as a theological controversialist, and was burnt to death as a heretic at the instigation of John Calvin, at Geneva. He was educated as a physician, as well as in many other varied branches of learning. He bestowed much thought and attention upon the study of the anatomy of the human body. Strong claims have been made on his behalf as the discoverer of the so-called pulmonary circulation, and there can be no doubt that in his "Restitutio Christianismi," in 1553, he suggested that since the blood could not pass through directly from one side of the heart to the other that, therefore, it must pass round by way of the lungs.

Speaking of the "elaborated subtle blood communicated from the right ventricle to the left," he says: "That communication does not, however, as is generally believed, take place through the median wall of the heart, but by a signal artifice the subtle blood is driven by a lay passage through the lungs. It is prepared by the lungs, is rendered yellow (light), and from the artery-like vein is poured into the vein-like artery. Then, in the vein-like artery (pul. veins) it is mixed with the inspired air, and by expiration is cleansed from its fumes. And so at length it is drawn in, a complete mixture, by the left ventricle through the diastole, stuff fit to become the vital spirit. That the communication and preparation does take place in this way through the lungs is shown by the manifold conjunction and communication of the artery-like vein with the vein-like artery. This view is confirmed by the conspicuous size of the artery-like vein, which would not have been made so large and so stout, and would not discharge from the heart itself such a power of very pure blood into the lungs for the mere purpose of nourishing these organs."

Servetus still regarded the liver as the fountain-head of the blood, and if he has any reference to the moving power in connection with the heart it is nothing more than the diastole or dilatation of the organ.

Realdus Columbus (1516-1559) succeeded for a short period his *slightly older* contemporary and quondam master, Vesalius, at

Padua, in 1544. He was appointed to a chair in Pisa in 1545, and, later, in Rome in 1558. He figures largely as a rival and imitator of Vesalius, though he also has been vaunted as an anticipator of Harvey, and, in some respects, his teaching as regards the lesser circulation approximated pretty closely to the truth ; his theories were vitiated by many of the old errors. In spite of his advanced views he shows little acumen and no perception of any really new principle. Thus, he still held the liver to be the origin of all the veins and the centre for the elaboration of the blood, the centre, also, from which blood is conveyed to the stomach and intestines, both to give nourishment and to take in nutritive material by the portal vein. He also denied the muscular nature of the heart, and held that the vena cava by its ramifications carries the blood from the liver for the maintenance of every part of the body. Altogether his views represent no real advance upon those, *e.g.*, of Servetus, from whom there would seem to be a probability that he actually plagiarised.

Andreas Cæsalpinus (1519-1603) was Professor of Anatomy at Pisa, 1567-1592, and at Rome from 1592-1603. In a work published in Florence in 1569 he actually speaks of a "circulation through the lungs." He also notes the swelling of veins distal to a ligature, and speaks of the exit of blood from the left ventricle and of its reception by the aorta for general distribution. It might thus be imagined that he had actually reached the truth, as some would have us believe. But how far he still was from any genuinely new conception is shown by his continuance in the old way of speaking of a tidal flux and reflux of blood in the veins. He explains the swelling of the vein distal to the ligature as due to the hasty effort of blood to get back to the heart lest it should be suffocated in the peripheral regions. He even still believes the septum to be permeable ; that the dilatation of the heart and arteries is due to an "effervescence of the spirits," and that their collapse is due to the appropriation of nutritive matter by the other parts of the body. Cæsalpinus, in fact, believed that the heart was not concerned as a cause of movement, but that this was due to the spirit inherent in, or associated with, the blood. Nevertheless it must be admitted that Cæsalpinus had not only recognised an actual pulmonary or lesser circulation, but had also made considerable progress towards the conception of the greater or systemic circulation, inasmuch as he recognised that through the veins blood returns to the heart, and that the " supply of blood and of spirits " is conveyed to the arteries and thence to the parts of the body. Still, he held that the outward movement by way of the arteries only occurs when we are awake, whilst the movement in a contrary direction towards the heart takes place during sleep.

We have now traced in brief outline the evolution of the knowledge of the physiology of the heart and blood vessels from ancient times till well on in the period of the revival of learning. The fuller development of the solution of the problem in the hands of Harvey is therefore not to be considered as by any means one of the first fruits of the Renascence movement. Rather was it the product of maturity, coming as a witness to the fact that modern science had outgrown its infancy, and had cast off the leading strings of antiquity which had necessarily guided its more immature imaginings.

William Harvey was born at Folkestone in 1578. He was thus a contemporary of Shakespeare, though his junior by fourteen years. He was also eighteen years younger than Lord Bacon, whose medical attendant he became. Among his younger contemporaries may be numbered John Milton, John Locke and Isaac Newton.

He was educated at the Grammar School of Canterbury, and at Caius Gonville College, Cambridge, where he graduated B.A. in 1597. He then proceeded to the continent, as it was then customary for young Englishmen about to study medicine to enter at one of the celebrated medical schools of France or Italy, Harvey went to Padua, where he studied under Fabricius, and after five years' study there he graduated as M.D. in 1602. Returning to Cambridge he took his *ad eundem* M.D. there in the same year, and in 1604 he joined the Royal College of Physicians in London, being admitted to the Fellowship in 1607.

His professional career seems to have been one of almost uninterrupted success. He became a physician to St. Bartholomew's Hospital in 1609, and in 1615 he was chosen to Lecture on Anatomy at the College of Surgeons and Physicians. It is generally agreed that in the following year he presented a detailed exposition of those views concerning the circulation, which have ever since been associated with his name. In 1623 he became a Physician Extraordinary to King James I., and some years later he formally became Ordinary Physician to Charles I. His connection with the Court had meanwhile become a close one, and his position in life a remunerative one, though he was heard to say that after his book on the circulation of the blood came out he "fell mightily in his practice; 'twas believed by the vulgar that he was crack-brained, and all the physicians were against him."

Although Harvey had publicly divulged his views on the circulation as early as 1616, and had probably actually written on them as early as 1619, his great work did not appear till 1628. (Bacon's celebrated "Novum Organum" had meanwhile appeared in 1620).

The nature of Harvey's contribution to the knowledge of the motion of the heart and blood was two-fold: firstly, he demonstrated that the heart alone was the means whereby the blood was propelled; secondly, he proved that in spite of the apparent difference between venous and arterial blood, it was essentially the same blood which was common to both arteries and veins.

These two propositions are in direct contrast with the older views, to wit, that (1) the heart was a mere passive cistern, the laboratory of the vital spirits; (2) that the moving power of the blood was the respiratory act.

Harvey's demonstration was the result of experiment upon living animals. Mere dissection of dead bodies had failed to afford the needful clue, and even with the actual living mechanism before him Harvey remarks that "when he first essayed himself to comprehend the motions of the heart, and to make out the uses of the organ," he found the subject so beset with difficulties that he was "almost inclined at one time to say with Fracastorius that these motions and their purpose could be comprehended by God alone."

Even in the end the utmost that Harvey could do was to leave the doctrine of the circulation of the blood as an inference of such a degree of probability that no unprejudiced mind could refuse to accept it. But the actual ocular demonstration of the passage of the blood in the arteries through the capillary vessels into the veins, and so back to the heart, was out of Harvey's reach. He had to assume that the blood percolated through the parenchyma of the lungs to get from the pulmonary artery to the pulmonary veins. The actual capillary continuity of the arteries and the veins was only rendered possible to the anatomist, Malphigi (who was born in the very year

of the publication of Harvey's famous work), by the rapid improvement in optical appliances which took place at about this period.

As in the case of nearly every other discovery of comparable importance, Harvey's inspired extreme opposition as well as cordial acceptance and support. For a while controversy raged bitterly, but gradually the old views died out as the older men were replaced by the younger and less conservatively minded generation. I would refer, in passing, to one only of the controversies carried on, since Harvey's views were, in this instance, advocated by the renowned René Descartes, "the father of modern philosophy." His opponent, Plempius, Professor at Louvain, seems to have been a person of singular and admirable candour—rare enough in the history of scientific or other controversy—for, at a later date, he relates that "this discovery did not please me at all at first, as I publicly testified both by word of mouth and in my writings, but, by and bye, when I gave myself up with firmer purpose to refute and expose it, lo, I refute and expose myself, so convincing, not to say persuasive, are the arguments of the author: I examine the whole thing anew with greater care, and, having at length made dissection of a few live dogs, I find that all his statements are most true."

It must not be supposed that the doctrine of "spirits," animal, vital, and natural, which we have seen to play such an important part in the explanation of the offices of the heart and blood from times of antiquity onwards, was straightway set aside or even directly affected by the new discovery. Harvey himself still utilises the old conceptions in his description of arterial blood and elsewhere, and the old terms were in use for over a century among scientific writers. They survived even much longer than this in old-fashioned physic, and so firm was their hold upon the popular consciousness that their phraseology, as I have already pointed out, is not extinct even to-day. Which of us has not heard such a familiar expression as "overflowing with animal spirits," though we may have failed to recognise that we were listening to the technical language of ancient and mediæval physiology?

But old ideas were not at once wholly overthrown by Harvey, still there had been introduced into the growing thought of anatomical and physiological science, not a new fact merely, but a new central conception of bodily structure and function. There is no function, and hardly an aspect of function, which is not so intimately dependent upon the hypothesis of a circulating, nutritive and oxygenating fluid as to render its interpretation wholly impossible apart from such a conception. How great, then, was the liberating and vivifying influence of Harvey's great contribution to human knowledge upon every branch of anatomical and physiological study, as well as upon the more directly practical interests of medicine and surgery!

Our consideration of the steps leading up to this greatest, because most fundamental biological discovery of modern ages, has been, I fear, somewhat tedious. But I will not apologise for the employment of the historical method, but only for my shortcomings in its application. There is no intellectual discipline more wholesome and necessary than that which enables us, to a greater or lesser extent, to realise by what steps both things themselves, and our knowledge of them, have come to be what they now are.